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Determination of the Proportions in Mortar and Concrete.

By C. R. PLATZMANN.

THE April 1935 number of CEMENT AND CEMENT MANUFACTURE contains an article by Mr. R. H. H. Stanger and Messrs. Woodcock and Mellersh on the analysis of concrete with the object of discovering the proportions used. An investigation of this type is of great importance, especially in the case of complaints, and it may be of interest to describe how this determination is carried out in Germany.

Proportions in Lime Mortar.

An average sample of lime mortar is ground as finely as possible, and 5 g. are dissolved in 25 c.c. of N-HCl and, after diluting with water, heated nearly to boiling point. The solution is filtered and washed with hot water until there is no reaction for chlorides. After cooling, a few drops of phenolphthalein are added as an indicator and the solution titrated back with N-NaOH. For instance, if three such tests give an average of 11.2 c.c. NaOH then the volume of N-HCl used for dissolving 5 g. of mortar is $25 - 11.2 = 13.8$ c.c. This corresponds to 0.504 g. HCl or 0.69 g. $CaCO_3$. The 5 g. therefore contain 0.69 g. $CaCO_3$ and 4.31 g. sand. Since the lime was used as calcium hydrate there were 0.51 g. $Ca(OH)_2$. The lime was, however, used as a paste comprising half water and half lime, so that there are 1.02 g. of paste.

The proportions by weight are 1.02 to 4.31 (sand) $= 1 : 4.25$ The proportions by volume, taking the specific gravity of lime as 1.3 and of sand as 1.6, are $\frac{1.02}{1.3} : \frac{4.31}{1.6} = 1 : 3.42$.

Proportions in Cement Mortar.

As various cements require different amounts of hydrochloric acid for solution the cement used (1 g.) must be dissolved in 25 cc. N-HCl and titrated back with

N-NaOH, using phenolphthalein as indicator; 18 cc. N-HCl were required in a test (this is the usual average value). Several average samples of the mortar (5 g.) were treated in the same way and an average figure of 14.2 cc. N-HCl was obtained. The amount of cement present is calculated from $\frac{14.2 \times 1}{18} = 0.79$ g. cement in 5 g. mortar and there are therefore 4.21 g. sand. The proportions by weight are 1 : 5.3 and the proportions by volume are calculated as follows: $\frac{0.79}{1.25} : \frac{4.21}{1.6} = 1 : 4.17.$

Proportions in Concrete.

F. Killig describes the following method:

After it has been crushed to pea size the sample is dried at about 100 deg. C. to constant weight. From the well-mixed material a sample of 400 to 500 g. is taken, crushed again, and again dried to constant weight at 100 deg. C. Of this, 100 g. are weighed after cooling and dissolved by stirring in cold dilute HCl in a large porcelain basin. When the evolution of CO_2 has ceased the insoluble sand and gravel portion is filtered off through a large folded filter or on a suction filter. This is now washed on the filter, first with cold water then with hot water, until the filtrate is free from lime, i.e. until no turbidity is produced in a solution of ammonium oxalate. The filter, sand, and gravel are dried at 105 deg. C. in an oven and weighed. For instance, if 78 to 82 g. sand are obtained the proportions are 1 : 4.

The filtrate should also be investigated. It is evaporated twice until the dissolved silica separates and the residue is taken up with water and some dilute HCl. The filtrate is collected in a 500-cc. measuring flask and made up to the mark; 100 cc. of this are run into a beaker, heated to boiling, and the sesquioxides precipitated with ammonia. After filtering and washing well the lime is precipitated with ammonium oxalate in the usual manner. The precipitate and filter are burnt off in a platinum crucible and ignited on the blowpipe to constant weight. The weight of CaO obtained multiplied by 5 gives the amount of lime in the cement. If the lime content of the cement is taken as 62 per cent. and 13.2 g. CaO are obtained from 100 g. concrete, the amount of cement is $13.2 \div 0.62 = 21.3$ g. which corresponds to proportions of 1 : 4 and a check on the first result is obtained.

These methods can give reliable results if the aggregate is free from lime. If it contains lime in considerable amount, then the first determination will give too low and the second too high a result. If the amount of limestone in the aggregate is not too large the determinations can be carried out neglecting the errors and a mean of the two values taken as the correct proportions.

R. Grün describes a somewhat different procedure which is claimed to be more reliable as it affords better control. The material is air dried, and 3 kg. are treated with dilute HCl. When the cement has gone completely into solution it is poured off with the " slip " that has formed. After settlement, the silica of the cement which has separated out is removed with caustic soda solution

and the residue is dried.   The separation of silica during the solution of the cement can be prevented completely by the following procedure.   The pulverised mortar or concrete is boiled with water and then mixed with 1 : 1 HCl equal to one-half of the original amount of water used so that a 3 : 1 HCl mixture is finally obtained.   This avoids the use of NaOH solution, which in some circumstances dissolves clay material also.   If the weights of the aggregate and the solids in the " slip " are now added together and the result subtracted from the original material the amount of hardened binding material, i.e. hydrated cement, is obtained.   The loss on ignition of a further average sample of the mortar or concrete enables the amount of unhydrated cement to be determined and the proportions by weight can be calculated.   The following example is given : Sand and gravel, 70.7 per cent. ; solid portion in the slip, 1.3 per cent. ; total aggregate, 72 per cent.; cement, 28 per cent.; CO_2 and H_2O free, 21.6 per cent. This gives the proportions of 1 : 3.3 which can be converted to volume proportions in the usual way.

Frequently the aggregate contains also a portion which is soluble in hydrochloric acid.   In such cases the determination of the proportions can be made approximately if the aggregate can be analysed.   The proportion of cement to sand and gravel obtained by the method described usually gives a value which is too high on the side of the cement.

To avoid inaccuracy the method must be extended by further analysis. From the analysis the amount of silica which goes into solution and the amount of lime dissolved by the HCl can be obtained.   These figures can be used as a basis for calculating the proportions.   A necessary preliminary for this type of calculation is a knowledge of the type of cement used (Portland cement, iron Portland cement, blast-furnace cement).   In addition, the amount of soluble material in the aggregate must not be very large.   For instance, if the calculation is for a Portland cement with 64 per cent. CaO, 22 per cent. SiO_2 and 10.2 per cent. CaO is obtained from the concrete

$$\frac{100}{64} = \frac{x \ (\%\text{cement})}{10.2} \quad x = 15.9.$$

Hence there is 84.1 per cent. aggregate, and the proportions are 1 : 5.3.   If the calculation is based on the silica content and 3.3 g. soluble silica were obtained in the analysis of the concrete, the calculation is

$$\frac{100}{22} = \frac{x(\%\text{cement})}{3.3} \quad x = 15.0.$$

There is therefore 85 per cent. aggregate present and the proportions are 1 : 5.7. The agreement is in this case very good compared with the possible limits of error.

In general the calculation from an analysis of a concrete is made as follows : If a cement contains a per cent. CaO or SiO_2 and the concrete b per cent. CaO or SiO_2, then

$$\frac{100}{a} = \frac{x}{b} \quad , \quad x = \frac{b.100}{a}$$

B

From this it follows that the amount of aggregate is $100 - \dfrac{b \cdot 100}{a}$ and the proportions by weight

$$\frac{\text{aggregate}}{\text{cement}} = \frac{100 - \dfrac{b \cdot 100}{a}}{\dfrac{b \cdot 100}{a}} = \frac{a}{b} - 1$$

The analysis of the concrete can be made use of further if the chemical composition of the aggregate is known, since the soluble portion in the aggregate can be calculated from the amount of insoluble matter present. This is subtracted from the concrete and the cement content can be obtained.

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R. Grün : Mörtelbindemittel in Berl-Lunge : Chemisch-technische Untersuchungsmethoden III. Band, 8. Auflage (Julius Springer, Berlin.)

The Hydrated Calcium Silicates.—By H. Kühl and A. Mann [*Tonind. Zeit.*, pp. 896, 918, 930, 944, 955, 990, 1003, 1014 (1934)]. An historical survey of past work on the calcium silicates is given and summarised as follows.

The cause of the hardening of Portland cement is a colloidal hydrated calcium silicate. Calcium silicates and their hydrates suffer hydrolysis in contact with water, the solid product being SiO_2aq. Hydrolysis comes to a standstill when the solution attains a certain lime content and reaches an equilibrium between the $xCaO.ySiO_2.zH_2O$ thus formed and the lime water at this concentration. The investigations have shown that $3CaO.SiO_2$, $\beta\text{–}2CaO.SiO_2$, and $\gamma\text{–}2CaO.SiO_2$ hydrolyse even in saturated lime water, while $CaO.SiO_2$ hydrolyses in saturated lime water with the formation of compounds richer in lime but in this case it is uncertain whether the lime is adsorbed or chemically combined. The existence of a hydrated monocalcium silicate has been established. Systems containing various molecular proportions of $CaO:SiO_2$ have been investigated in order to discover more basic hydrated calcium silicates. The results gave compounds with $CaO:SiO_2$ from $1.1 : 1$ to nearly $2 : 1$. It has been assumed that a compound of the formula $3CaO.2SiO_2$.aq. is stable in contact with saturated lime water.

Further work in these directions was required, and this was undertaken by the authors. The reactions between calcium hydroxide solutions and various silicate melts have been systematically examined. The silicate melts varied from 0 to 2 molecules of CaO to each molecule of SiO_2. It has been shown that a hydrated silicate lower in lime than $CaO.SiO_2$.aq. does not exist. A gel of the composition $CaO.SiO_2$.aq. is stable in a solution of lime water containing 0.131 g. CaO per litre. A series of gel-like hydrated calcium silicates which starts at the composition $CaO.SiO_2$.aq. and approaches the composition $2CaO.SiO_2$.aq. has been observed. The particular gel compound which is formed on the hydration of a calcium silicate melt containing more than one molecule of CaO to one molecule of SiO_2 depends on the lime concentration of the liquid phase. The most important fact is that in the presence of saturated lime water the stable gel-like hydrated calcium silicate contains exactly three molecules of CaO to two molecules of SiO_2.

Extension of the Cement Works of the Coltness Iron Company, Ltd.

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(Concluded.)

BLENDING SYSTEM UNDER REMOTE CONTROL.—Fig. 8 illustrates the automatic control board in the laboratory under the supervision of the chemist.   By this remote control extremely complex and frequent variations in the delivery points of the mill-stream and circulating-stream are easily made.   The two conveying systems are interlocked and controlled as a single unit and operated from the control panel.   The system can operate automatically without attention, but if
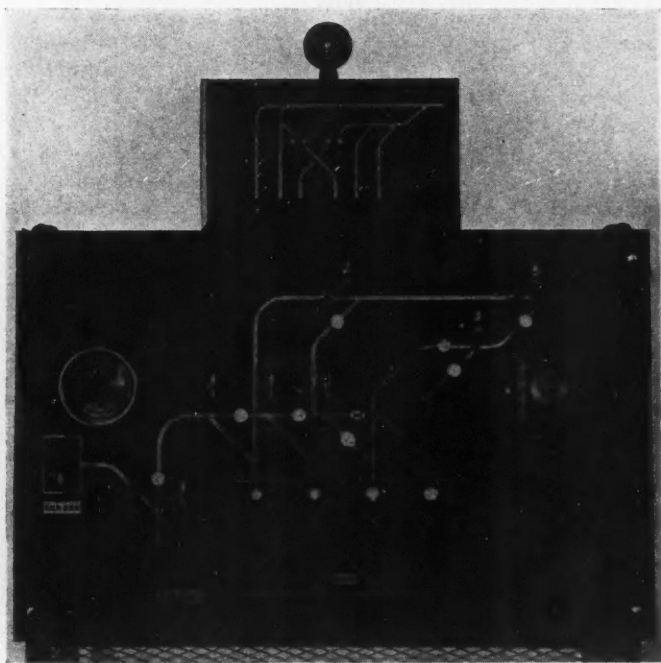

Fig. 8.

for some reason raw material should be diverted immediately from the mill-stream or from the circulating-stream, separately or simultaneously, it can be sent instantly to the new delivery point by the operation of a remote control switch forming part of the control panel.

By means of this control board the chemist operates and controls the distribution of raw material through the various branch lines of the two systems (mill-stream and circulating stream) in a predetermined sequence and for any desired period of time. Thus the quantity of raw material delivered to any silo or to the kiln feed hopper at a given time is determined by the rate and time interval of delivery rather than the capacity of the bin to receive material. If a silo or bin is full it is by-passed automatically until it can again receive material. A standard time unit, adjustable from the front of the panel, controls the operation of the distributing valves at any desired interval from two to sixty minutes. The two Fuller-Kinyon systems are synchronised under this control to function as a unit. This timed automatic control is used in blending the dry raw materials in accordance with the Fuller or layer method by which mill-stream and kiln-delivery are synchronised with silo circulation. Deliveries can be made singly or to any grouping of silos by all or any combination of systems for any time interval.

On the control board are shown diagrammatically the two Fuller-Kinyon systems and their distribution branches. Blue lights on the mill stream and red lights on the blending stream indicate the direction of material flow at all times. Green lights in the rectangles indicating the four silos and the kiln bin remain lighted so long as the bins have capacity to receive material. Fig. 8 shows the position of the valves, which are electro-pneumatically controlled, and their remote control switches which have three positions to provide for automatic, remote control, or seal silo or kiln bin.

With these arrangements it is possible to obtain a uniformly high quality cement by the dry process in making use of the improved dry blending methods which have now been in operation in many dry process cement plants in the United States for some years. The layer system is based on the characteristics of dry materials and makes use of their behaviour in handling and in storage. As an example, pulverised materials which have been transported or pumped by a conveying system in an aerated condition have no tendency to separate or classify according to specific gravity or fineness. When discharged into a bin the materials assume a flat or hydrostatic level due to the quasi-liquid condition, and when two systems discharge simultaneously into the same silo a partial mixture results from the turbulent flow.

One of the factors contributing to better mixing is the characteristic of dry pulverised materials when withdrawn by gravity from a storage bin or silo to form pipes or " rat-holes " above the discharge spouts throughout the entire height of the material in the silo or bin. Materials thus discharged are the product of almost all levels from top to bottom rather than the lowest material in storage. Advantage of this is taken in the present system by forming thin flat layers of a fraction of the mill stream load in each bin automatically. Equal or variable fractions of materials are withdrawn from each of the raw storage silos and recirculated, together with a small quantity of flue dust which is delivered as it accumulates. In the installation described the entire system operates

continuously without complicated supervision if the mill stream error does not vary beyond usual conditions. If this takes place the automatic operation can be modified by remote control and the variation rectified by the correct apportioning of raw material elements correctly blended as mentioned later.

When the installation is operating as a unit the most important factors contributing to the ultimate mixture are (1) the spread of the mill stream error over the number of silos available, in this instance four ; (2) the effect of collection,

Fig. 9.

circulation, and blending of the first two and the third and fourth silos by discharge into the same pipelines and by delivery in sequence to each of the four silos ; (3) the turbulent action of the two discharging streams ; (4) the number of " rat-holes " in each silo ; (5) the delivery of the kiln intermittently and alternately from the first two and the second two silos ; and (6) delivery to the kiln bin at similar time intervals to form thin flat layers in the kiln bin, which run together similarly during withdrawal by the kiln feeders. When the bin is filled the branch line over the kiln bin connected to the withdrawal transport line is by-passed by the automatic control.

The system is so arranged that blending may be accomplished by proportioning and correcting. For example, if the normal materials are low in lime the mill stream may be circulated in three of the four silos and a high-lime material delivered to the fourth silo. Blending is then accomplished by proportioning withdrawals from the first three silos and the fourth silo for effecting an ultimate mixture in collection and delivery by the layer system to the kiln bin. The system permits as many variations of operations as may be required. The total energy used by the automatic control and blending system does not exceed 2 kilowatt hours per ton of cement for the whole plant.

A sampling device (Fig. 9) fitted on each main conveying line (mill stream and circulating stream) in a suitable place for easy inspection can give a continuous sample over two or more hours of each stream in collecting the sample into a bucket under pressure equilibrated with the conveying line ; alternatively, an instantaneous sample at any given time may be obtained by discharging it directly into any sampling box under atmospheric pressure. The samples of raw materials so taken have been thoroughly mixed by the blasting effect of the compressed air admitted at the air ring of the pump, and consequently they give an accurate idea of the composition and analysis of the raw material at any given time, or an average over any period of time. Such control is most important and when properly used makes certain of the uniformity of the resulting clinker and cement. The complete new Fuller-Kinyon system is diagrammatically illustrated in Fig. 11.

The Kiln.

Extensive modifications were executed in connection with the No. 2 Pfeiffer 131ft. kiln previously described. The main alteration consisted in the entire removal of the two lower sections, approximately 15ft. 1$\frac{1}{2}$in. overall length. The new plates were of $\frac{3}{8}$in. boiler-quality mild steel supplied with one circumferential butt strap 20in. wide by $\frac{3}{8}$in. thick, a longitudinal butt strap 14in. wide by $\frac{3}{8}$in. thick, and one wrapper under the existing tyre 26in. wide by $\frac{5}{8}$in. thick at the lower end. This tyre (Fig. 10) is situated at the extreme lower end of the kiln, and another wrapper 36in. wide by $\frac{1}{2}$in. thick was fitted under the recuperator outlets.

A completely new cooling system was fitted, comprising ten cylinders each 3ft. 6in. internal diameter by 14ft. long, bolted to the shell of the kiln and receiving clinker through five twin cast-steel outlet chutes. This recuperator is of the normal Vickers-Armstrongs " Reflex " type and was supplied and fitted by that firm. The coolers have special linings of heat-resisting cast iron and are fitted with the new type cone end. With the old Pfeiffer cooler burning took place very near the outlet end of the kiln, and only a short burning pipe was used. In order to increase the efficiency of the cooling a new burning pipe of greater length was installed, and from the point of view of output some of the effective length of the kiln was thereby taken away. The burning pipe was supplied by Vickers-Armstrongs and is of the air-jacketted type. A separate booster fan was installed to supply the air entering the kiln through the annular space surrounding
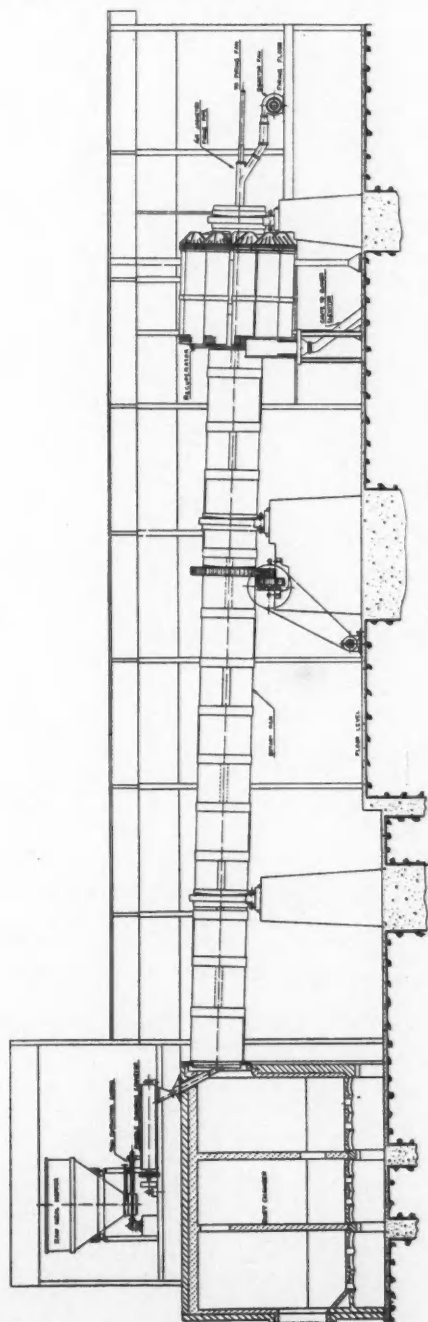
Fig. 10.—Section through Kiln showing New Feed, Drive, Cooler and Firing arrangements, etc.

SECTION B.B.

PLAN.
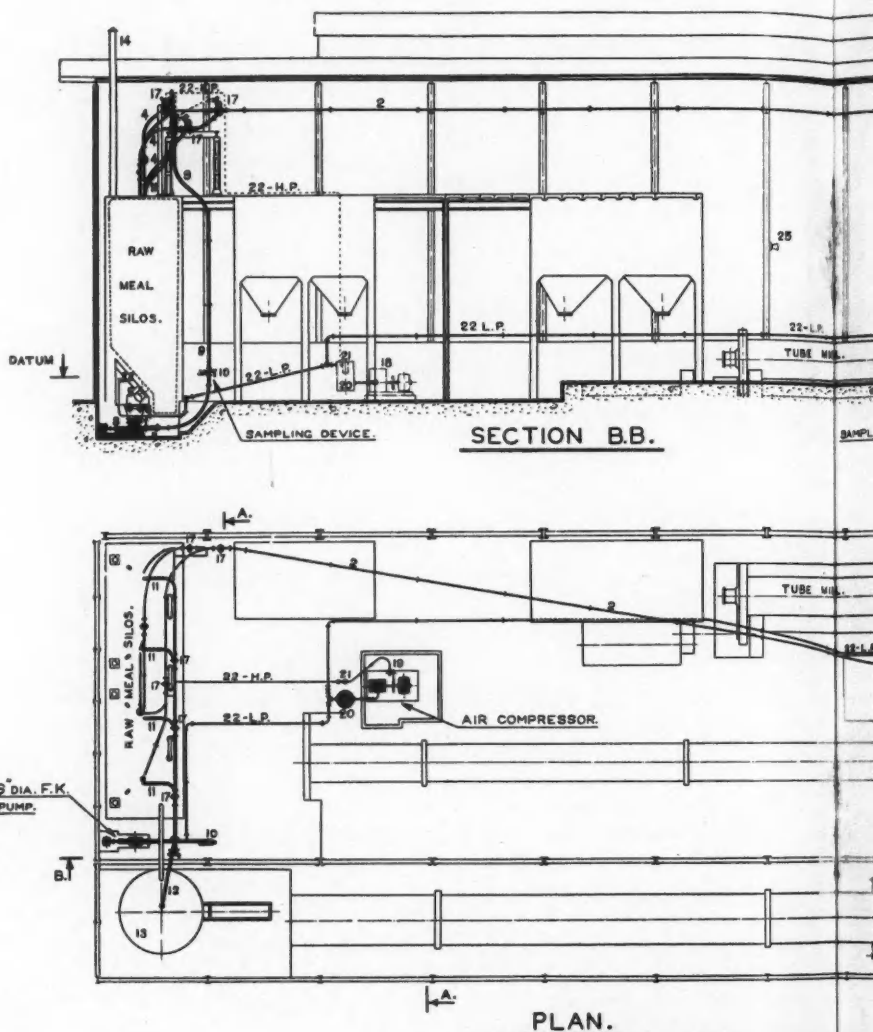
Fig. 11.—Outline arrangement of Fuller-Kinyon
for Dry Raw Meal, Slurry Pumps, Pipe

1. 5in. Fuller-Kinyon pump. 2. 3½in. meal stream
conveying line. 3. Meal sampler. 4. Stream
branches to silos. 5. Silo proportioning gates. 6. Two
screw conveyors. 7. Flue dust conveyor. 8. 6in. Fuller-
Kinyon pump. 9. 5in. circulating and blending con-
veying lines. 10. Circulating and blending sampler.
11. Circulating and blending branches to silos. 12.
Branch delivering to kiln bin. 13. Kiln bin. 14. Vent
stacks. 15. High level signals. 16. Low level
signals. 17. Two-way valves with electro-pneumatic
units. 18. Main compressor (low pressure). 19. Auxiliary

RAW MEAL SILOS.

SECTION A.A.

DATUM

SAMPLING DEVICE.

5" DIA. F.K. PUMP.
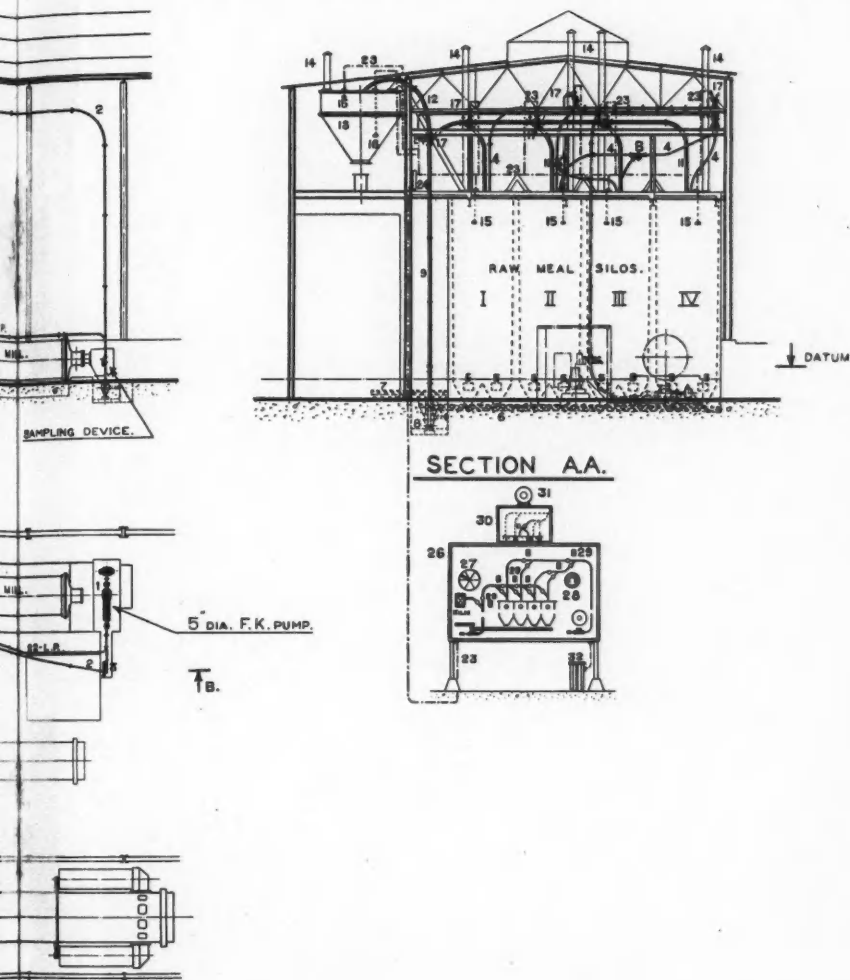
Müller-Kinyon Transport and Mixing System
Pumps, Pipe Lines, Air Compressors, etc.

compressor (high pressure).   20. Main air receiver (L.P.)
21. Auxiliary air receiver (H.P.).   22. Air lines (L.P. and
H.P.).   23. Electric wiring.   24. Connection board.   25.
Main klaxon sounding when all silos are full.   26. Timed
automatic control board for blending system. 27. Timer
(6 cycles).   28. Automatic contact repeater (0 to 60
minutes).   29. Levers of remote control switches (three
positions: automatic, hand-operated control, sealed
silo or bin).   30. Auxiliary board for hand-operated
valves A and B.   31. Warning signal sounding when
any silo or kiln is filled.   32. 1 Kva. transformer.

the pipe.   The kiln is still supplied with coal by the same " Attritor " as before, arrangements in this respect being unaltered.

Clinker Handling.

A mild-steel discharge chute collects the clinker from the cylinders and delivers it to a weighing machine and then to a totally-enclosed vertical bucket elevator with 10in. buckets and 53ft. centres supplied by Boby and Co. and constructed upon similar lines to that previously used.   The elevator is driven by a 4-h.p. motor running at 960 r.p.m., and has a capacity of 12 tons of clinker per hour.

Previously clinker was transported by a ropeway separated by a gantry leading to the clinker silos.   In order to save expense an effort was made to use this gantry to carry a belt conveyor, and this was done.   The clinker is delivered from the elevator to a troughed belt 14in. wide by 175ft. centres, which is fitted into and carried by the gantry.   The conveyor was also supplied by Boby and Co., and is driven by a 5 h.p. motor running at 750 r.p.m.   Although it is somewhat cramped, the arrangement worked out quite well.   The belt conveyor delivers clinker either directly to one of the clinker silos or to a second belt conveyor travelling over the top of the silos and carrying it into the clinker store.   This conveyor, which is 14ft. wide by 100ft. long and is driven by a 4 h.p. motor running at 960 r.p.m., can spout clinker directly into the store or alternatively on to a cross reversible conveyor 14in. wide by 65ft. centres to increase the store capacity.

General.

Orders for the new plant were placed in January 1934 and in August the new machinery was first lightly run.   In September the plant was put into production, and after six months it had decreased production costs and improved the quality of the clinker.   In addition, the kiln output has improved from 90 to 93 tons per day to over 100 tons, in spite of a reduced effective length.   The back-end gas temperature has not altered much, but the cooling of the clinker is more effective, the temperature not exceeding 200 deg. F.   With the finer raw materials, an improvement of 10 per cent. to 15 per cent. is shown in coal consumption.   The new arrangement is much simpler in operation and more easy to control.   The works described completes the first stage in the intended modification of the plant. Messrs. Vickers-Armstrongs, Ltd., Barrow-in-Furness, acted as main contractors for the work, while the electrical installation was undertaken by the Coltness Iron Co.'s staff.

Uncombined Lime in Portland Cements.

By W. WATSON, B.Sc., and Q. L. CRADDOCK, M.Sc.

MUCH uncombined calcium oxide in cement clinker generally produces a cement which will fail to pass the soundness test.   It is therefore advisable, especially in researches on synthetic cements, to have reliable methods for the qualitative and quantitative estimation of uncombined lime.   Factors affecting the presence of uncombined lime are : (1) Temperature and duration of burning ; (2) Composition of the raw mixture—if the calcium oxide present is more than sufficient chemically to saturate the acidic components of the mix free lime must be present ; (3) The fineness and homogeneity of the raw mixture—White[4] instances a case of a coarse raw mixture which showed uncombined calcium oxide after burning at 1,612 deg. C. ; the same mixture finely ground gave no free lime when burnt for the same time at 1,475 deg. C. ; (4) The physical state of the constituents, e.g., presence of flints and sand.

Some investigators still maintain that calcium oxide is present in all normal Portland cement clinker.   This is quite untrue.   A free lime content of over 2 per cent. is a rarity in well-burnt clinker.   Previous methods of determining free lime which have since proved to be inaccurate are probably responsible for this idea of a high free lime content.

Qualitative Detection.

(1) MICROSCOPIC DETECTION[1,2,3].—Calcium oxide in particles of sufficient size for microscopical observation may readily be recognised as fine isotropic grains, usually rounded in outline and of a very high refractive index (1.83).

(2) WHITE'S TEST.[4]—This test is based on the fact that phenol readily reacts with calcium oxide with the formation of calcium phenate, the crystals of which have a characteristic appearance in polarised light.   White's reagent is prepared by dissolving 5 gr. of phenol in 5 c.c. of nitrobenzene, with the addition of two drops of water ; α-bromonaphthalene is a less volatile solvent, but it does not give such sharp results as nitrobenzene.   The finely ground cement is placed on a microscope slide, a drop of the reagent is added, and a cover glass is placed over the mixture and gently rubbed and pressed down.   The slide is then observed with polarised light.   If " light-burnt " lime is present the edges of the particles begin to show brilliant points which develop rapidly into bright radiating needles if much uncombined lime is present.   If many phenate crystals appear in thirty minutes the cement will be unsound by the Le Chatelier test.   When a longer time is required for the crystals to appear the cement is usually sound.   In the presence of " hard-burnt " lime the phenate crystals appear as plumes or feathery crystals.   This test has been confirmed by Reibling and Reyes.[5]

Other qualitative tests used by Richter[6] and Hertschel[7] are not considered to be as reliable as White's, which is very sensitive and is applicable for the detection of calcium oxide in very small quantities.

Quantitative Estimation.

(1) BY EXTRACTION WITH AQUEOUS SOLUTIONS OF VARIOUS REAGENTS.— Since the various components of Portland cement clinker are extremely susceptible to hydrolysis with the formation of calcium hydroxide, the results obtained by such methods will inevitably give the sum of the free lime and the calcium hydroxide liberated by hydrolysis. No reliable method has yet been found for the determination of uncombined calcium oxide in the presence of the hydroxide. Owing to the risk of hydrolysis during commercial grinding of clinker satisfactory free lime determinations can only be made on freshly ground clinker without the addition of a retarding agent for regulating the setting time. Of the methods used by various workers that in which sugar solution is employed was at one time very popular. Aqueous solutions of sugar readily dissolved calcium oxide : a 5 per cent. solution of sucrose dissolves approximately 12 gr. of CaO per litre.[8] The lime compounds formed with the sucrose are readily hydrolysed and give an alkaline solution which is titrated with standard acid. Heldt[9], Levoir[10], Parsons[11], Zulkowsky[12], Rebuffat[13], Martin[14], and Leduc[15] have all used some modification of this method. That the true free lime value cannot be obtained by this method was shown by Michaelis[16] and Brady and McConnell[17].

(2) BY EXTRACTION WITH ALCOHOLIC SOLUTIONS OF VARIOUS REAGENTS.— Smith and Hendricks [18] used a method dependent on the reaction of an N/10 solution of benzoic acid in alcohol with lime. The excess acid is titrated with N/10 caustic soda. Lerch and Bogue[19] showed that the cement is attacked in the presence of dilute solutions of weak acids.

(3) GLYCEROL EXTRACTION METHODS.—These methods make use of the fact. that calcium oxide and hydroxide dissolve slowly in glycerol or mixtures of glycerol and alcohol with the formation of a compound which is readily hydrolysed The instability of the compound is such that it may be titrated as free alkali with an alcoholic solution of a weak acid, using phenolphthalein as indicator. The method was originally suggested by Maynard[20], and modifications have been introduced by Emley[21] who titrated the glycerol solution of CaO with ammonium acetate, Rathke[22] substituted tartaric acid for the ammonium acetate, and the Building Research Station[23] uses benzoic acid. The experimental modifications introduced by the Building Research Station[23] and Lerch and Bogue[24] [25] give results which are probably the most accurate obtainable at present. For the determination of free lime in Portland cement clinker the method of Lerch and Bogue is most accurate, while for testing hydraulic limes the Research Station method is preferable. Clinkers which show no trace of free lime by White's test were tested by the method of Lerch and Bogue with negative results for free lime, showing that no decomposition of the calcium silicates and aluminates takes place during the extraction process. A method which gives very fair agreement with the Lerch and Bogue method and is very much quicker is based on the work of Jander and Hoffmann[26] in which the glycerol extract is diluted with water after filtration and titrated with N/10 HCl.

(4) OTHER METHODS.—Brandenberg[27] used a method dependent upon the liberation of ammonia from ammonium bromide by the action of the free lime. The liberated ammonia is distilled over into standard acid, the excess of which is determined with standard alkali. This method when applied to pure CaO gives results which are consistently low. The use of brominated fatty acid of high molecular weight[28] and methyl iodide[29] as reagents for separating or estimating free lime have been suggested but are open to objections in all cases.

Estimation of Calcium Hydroxide in Set Cements.

(1) PASSOW'S METHOD[30].—In this method the calcium hydroxide is converted into calcium carbonate by heating with ammonium carbonate and the increased CO_2 determined gravimetrically. Brady and McConnell[17] substituted ammonium carbamate, NH_4COONH_2, for ammonium carbonate as the former gives no water due to decomposition. The method does not, however, give accurate results since the reaction between the dry powder and the gas is necessarily slow. Furthermore a crust of carbonate is formed on the surface of the particles which inhibits further reaction, and some attack of the other cement constituents also takes place.

(2) METHOD OF STRADLING AND BRADY[31].—This method makes use of the fact that calcium oxide has a high heat of hydration. The sample is heated to 900 deg. C. for ten minutes during which time all the calcium hydroxide is dehydrated, but no calcium carbonate is decomposed. After cooling, the heat of hydration is measured calorimetrically. This method cannot be regarded as anything but a rough guide, since it assumes that the only heat effect is due to hydration of calcium oxide, other factors being assumed to be negligible.

(3) THE CALORIMETRIC METHOD OF BAKEWELL AND BESSEY[23].—This method depends upon the fact that calcium hydroxide does not dissociate below 350 deg. C., while dissociation is nearly complete after ignition for thirty minutes at 550 deg. C. Samples of the material are ignited at each of these temperatures and the difference in the heat evolved on rehydration is measured. Corrections are applied for incomplete dehydration of calcium hydroxide at 550 deg. C. for carbonation of the sample and for combination of lime with other materials during ignition. This method is by far the most accurate for determination of calcium hydroxide in set cement.

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Book Reviews.

Researches on the Constitution of Portland Cement Clinker. By B. Tavasci. (*Journal of Industrial and Applied Chemistry, Milan*).—This monograph of 13 pages, written in the Italian language, describes investigations on the constitution of clinker using metallographic methods. Sections of commercial clinkers and of the pure silicates, aluminate, and alumino-ferrite of lime, were etched with various reagents, and there are 48 illustrations of photo-micrographs showing the results. The conclusions are drawn that alite is tricalcium silicate, belite is dicalcium silicate, and celite is a combination of tricalcium aluminate and tetra-calcium-alumino ferrite.

Researches on the Constitution of Fused Cement. By B. Tavasci. (*Chemistry and Industry, Milan*).—This work, also in the Italian language, describes a study on metallographic lines of aluminous cement and the pure aluminates and alumino-silicate of lime.

Density of Gases in Rotary Cement Kilns.

TABLE I.

WEIGHT IN GRAMMES PER LITRE OF GAS AT 0 DEG. C. AND ATMOSPHERIC PRESSURE
(760 MM. MERCURY).

Gas.	Formula.	Mol. wt.	Density (calc.).	Book of Reference.*				
				(1)	(2)	(3)	(4)	(5)
Air	—	—	—	1.2928	1.2928	1.2925	1.2928	1.2930
Carbon monoxide	CO	28.00	1.2493	1.2504	1.2504	1.2537	1.2503	1.2504
Carbon dioxide ..	CO_2	44.00	1.9632	1.9768	1.9768	1.9704	1.9766	1.9768
Nitrogen ..	N_2	28.02	1.2502	1.2505	1.2507	1.2537	1.2505	1.2507
Oxygen	O_2	32.00	1.4278	1.4290	1.4290	1.4330	1.4289	1.4290
Sulphur dioxide..	SO_2	64.06	2.8583	2.9270	2.9266	—	2.9268	—
Water vapour ..	H_2O	18.02	0.8040	0.8050	—	0.8060	0.8040	0.8040

TABLE II.

WEIGHT IN LB. PER CUBIC FOOT OF GAS AT 32 DEG. F. AND ATMOSPHERIC PRESSURE
(14.69 LB. PER SQUARE INCH).

Gas.	Formula.	Mol. wt.	Density (calc.).	Book of Reference.*				
				(1)	(2)	(3)	(4)	(5)
Air	—	—	—	0.08071	0.08071	0.08073	0.08071	0.08072
Carbon monoxide	CO	28.00	0.07799	0.07806	0.07806	0.07826	0.07805	0.07806
Carbon dioxide ..	CO_2	44.00	0.12294	0.12341	0.12340	0.12298	0.12340	0.12341
Nitrogen ..	N_2	28.02	0.07804	0.07807	0.07808	0.07826	0.07807	0.07808
Oxygen	O_2	32.00	0.08913	0.08921	0.08921	0.08944	0.08920	0.08921
Sulphur dioxide..	SO_2	64.06	0.17844	0.18273	0.18270	—	0.18270	—
Water vapour ..	H_2O	18.02	0.05019	0.05026	—	0.05031	0.05019	0.05019

TABLE III.

DENSITY OF GASES RELATIVE TO AIR = 1.

Gas.	For-mula.	Mol. wt.	Density (calc.).	Book of Reference.*				
				(1)	(2)	(3)	(4)	(5)
Air	—	—	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Carbon monoxide	CO	28.00	0.9664	0.9672	0.9672	0.9720	0.96710	0.9662
Carbon dioxide ..	CO_2	44.00	1.5186	1.5289	1.5290	1.5200	1.52890	1.5185
Nitrogen ..	N_2	28.02	0.9670	0.9673	0.9674	0.9720	0.96727	0.9669
Oxygen	O_2	32.00	1.1044	1.1053	1.1054	1.1020	1.10530	1.1044
Sulphur dioxide..	SO_2	64.06	2.2109	2.2640	2.2638	2.2100	2.26390	—
Water vapour ..	H_2O	18.02	0.6230	0.6230	—	0.6230	—	0.6218

In calculating the volumes and weights of cement kiln gases at various temperatures by Charles's Law, the following values have been taken for volumes and weights of gases at 0 deg. C. and 760 mm. Hg. pressure.

Gas.	Weight in gr. per litre of gas.	Litres of gas per gramme.	Weight in lb. per cu. ft. of gas.	Cu. ft. of gas per lb.
Air	1.2928	0.7735	0.08071	12.390
Carbon monoxide	1.2504	0.7997	0.07806	12.810
Carbon dioxide	1.9768	0.5059	0.12340	8.104
Nitrogen	1.2507	0.7995	0.07808	12.810
Oxygen	1.4290	0.6998	0.08921	11.210
Sulphur dioxide	2.9266	0.3417	0.18270	5.473

The volumes and weights of steam at atmospheric pressure (14.69 lb. per sq. in.) for various temperatures have been calculated from Callender's Steam Tables, which give the volume of 1 lb. of steam at one atmosphere pressure and 212 deg. F. as 26.789 cu. ft., i.e., 1 cu. ft. of steam at 212 deg. F. weighs 0.03733 lb.

Between 100 deg. F. and 200 deg. F. the density of aqueous vapour in air saturated with moisture has been taken from a table given in Kempe's *Engineer's Year Book for* 1929, p. 1984.

* (1) Bayley's " Chemists' Pocket Book," 1921, p. 204 ; (2) Kaye and Laby, " Physical and Chemical Constants," 1932, p. 28 ; (3) Kempe's " Engineer's Year Book for 1929," p. 1980 ; (4) Lunge's " Technical Chemist's Handbook," 1908, p. 16 ; (5) Chemical Engineering Catalogue.

TABLE IV.

WEIGHT IN LB. OF 1 CUBIC FOOT OF GAS AT ATMOSPHERIC PRESSURE
(14.69 LB. PER SQUARE INCH).

Temperature.		Air.	Oxygen.	Nitrogen.	Carbon monoxide.	Carbon dioxide.	Steam.	Sulphur dioxide.
Deg. F.	Deg. C.							
100	38	0.07090	0.07838	0.06859	0.06857	0.10840	0.00283 [1]	0.16040
150	66	0.06508	0.07195	0.06297	0.06295	0.09951	0.01031 [1]	0.14720
200	93	0.06015	0.06649	0.05819	0.05817	0.09197	0.02976 [1]	0.13410
250	121	0.05592	0.06180	0.05409	0.05408	0.08548	0.03533	0.12650
300	149	0.05224	0.05774	0.05053	0.05052	0.07987	0.03301	0.11820
350	177	0.04900	0.05418	0.04742	0.04740	0.07493	0.03097	0.11090
400	204	0.04615	0.05102	0.04465	0.04464	0.07057	0.02917	0.10440
450	232	0.04362	0.04822	0.04220	0.04219	0.06669	0.02756	0.09870
500	260	0.04135	0.04570	0.04000	0.03999	0.06322	0.02612	0.09355
550	288	0.03930	0.04344	0.03802	0.03801	0.06010	0.02483	0.08893
600	315	0.03745	0.04139	0.03623	0.03622	0.05726	0.02366	0.08473
650	343	0.03576	0.03953	0.03460	0.03459	0.05468	0.02259	0.08165
700	371	0.03422	0.03782	0.03310	0.03309	0.05232	0.02161	0.07743
750	399	0.03280	0.03626	0.03173	0.03172	0.05015	0.02071	0.07423
800	426	0.03150	0.03482	0.03047	0.03046	0.04816	0.01989	0.07128
850	454	0.03030	0.03349	0.02931	0.02930	0.04632	0.01913	0.06857
900	482	0.02918	0.03226	0.02823	0.02822	0.04462	0.01843	0.06604
950	510	0.02815	0.03111	0.02723	0.02722	0.04304	0.01778	0.06370
1,000	538	0.02718	0.03005	0.02630	0.02629	0.04157	0.01717	0.06152
1,050	566	0.02628	0.02905	0.02543	0.02542	0.04019	0.01660	0.05948
1,100	594	0.02544	0.02812	0.02461	0.02460	0.03890	0.01607	0.05758
1,150	621	0.02465	0.02725	0.02385	0.02384	0.03769	0.01557	0.05579
1,200	649	0.02391	0.02642	0.02313	0.02312	0.03655	0.01510	0.05410
1,250	676	0.02321	0.02565	0.02245	0.02244	0.03548	0.01466	0.05252
1,300	704	0.02255	0.02492	0.02182	0.02181	0.03448	0.01424	0.05103
1,350	732	0.02193	0.02423	0.02121	0.02120	0.03352	0.01385	0.04962
1,400	760	0.02134	0.02358	0.02064	0.02064	0.03262	0.01347	0.04828
1,450	788	0.02078	0.02296	0.02010	0.02009	0.03176	0.01312	0.04702
1,500	815	0.02025	0.02238	0.01959	0.01958	0.03096	0.01279	0.04582
1,550	843	0.01974	0.02183	0.01910	0.01909	0.03019	0.01247	0.04468
1,600	871	0.01926	0.02129	0.01864	0.01863	0.02945	0.01217	0.04360
1,650	899	0.01881	0.02079	0.01819	0.01819	0.02876	0.01188	0.04257
1,700	927	0.01837	0.02031	0.01777	0.01777	0.02809	0.01160	0.04158
1,750	955	0.01795	0.01985	0.01737	0.01737	0.02746	0.01134	0.04064
1,800	982	0.01756	0.01941	0.01699	0.01698	0.02685	0.01109	0.03974
1,850	1,010	0.01718	0.01899	0.01662	0.01661	0.02627	0.01085	0.03888
1,900	1,038	0.01681	0.01859	0.01627	0.01626	0.02571	0.01062	0.03806
1,950	1,066	0.01647	0.01820	0.01593	0.01592	0.02517	0.01040	0.03727
2,000	1,093	0.01613	0.01783	0.01561	0.01560	0.02466	0.01019	0.03651

[1] Lb. of water vapour per cu. ft. of saturated air at atmospheric pressure.

TABLE V.

VOLUME IN CUBIC FEET PER LB. OF GAS AT ATMOSPHERIC PRESSURE
(14.69 LB. PER SQUARE INCH).

Temperature.		Air.	Oxygen.	Nitrogen.	Carbon mon-oxide.	Carbon dioxide.	Steam.	Sulphur dioxide.
Deg. F.	Deg. C.							
100	38	14.10	12.76	14.58	14.58	9.23	353.00[a]	6.23
150	66	15.37	13.90	15.88	15.89	10.05	96.99[a]	6.79
200	93	16.63	15.04	17.19	17.19	10.87	33.60[a]	7.35
250	121	17.88	16.18	18.49	18.49	11.70	28.32	7.91
300	149	19.14	17.32	19.79	19.79	12.52	30.31	8.46
350	177	20.41	18.46	21.09	21.10	13.35	32.31	9.02
400	204	21.67	19.60	22.40	22.40	14.17	34.31	9.58
450	232	22.93	20.74	23.70	23.70	14.99	36.30	10.13
500	260	24.18	21.88	25.00	25.01	15.82	38.30	10.69
550	288	25.45	23.02	26.30	26.31	16.64	40.29	11.24
600	315	26.70	24.16	27.60	27.61	17.46	42.28	11.80
650	343	27.96	25.30	28.90	28.91	18.29	44.29	12.25
700	371	29.22	26.44	30.21	30.22	19.11	46.27	12.91
750	399	30.49	27.58	31.52	31.53	19.94	48.29	13.47
800	426	31.75	28.72	32.82	32.83	20.76	50.28	14.03
850	454	33.00	29.86	34.12	34.13	21.59	52.27	14.58
900	482	34.27	31.00	35.42	35.44	22.41	54.26	15.14
950	510	35.52	32.14	36.72	36.74	23.23	56.24	15.70
1,000	538	36.79	33.28	38.02	38.04	24.06	58.24	16.25
1,050	566	38.05	34.42	39.32	39.34	24.88	60.24	16.81
1,100	594	39.31	35.56	40.63	40.65	25.71	62.23	17.37
1,150	621	40.57	36.70	41.93	41.95	26.53	64.23	17.92
1,200	649	41.82	37.85	43.23	43.25	27.36	66.23	18.47
1,250	676	43.08	39.00	44.54	44.56	28.18	68.21	19.04
1,300	704	44.35	40.13	45.84	45.85	29.00	70.22	19.60
1,350	732	45.60	41.27	47.15	47.17	29.83	72.20	20.15
1,400	760	46.86	42.41	48.45	48.45	30.66	74.24	20.71
1,450	788	48.12	43.55	49.75	49.78	31.49	76.22	21.27
1,500	815	49.38	44.68	51.05	51.07	32.30	78.19	21.82
1,550	843	50.66	45.81	52.36	52.38	33.12	80.19	22.38
1,600	871	51.92	46.97	53.66	53.68	33.95	82.17	22.94
1,650	899	53.16	48.10	54.97	54.68	34.77	84.18	23.49
1,700	927	54.44	49.24	56.27	56.27	35.60	86.21	24.05
1,750	955	55.71	50.38	57.57	57.57	36.42	88.18	24.61
1,800	982	56.95	51.52	58.86	58.89	37.24	90.17	25.16
1,850	1,010	58.21	52.66	60.17	60.20	38.07	92.17	25.72
1,900	1,038	59.49	53.79	61.46	61.50	38.90	94.16	26.27
1,950	1,066	60.72	54.95	62.77	62.81	39.73	96.15	26.83
2,000	1,093	62.00	56.09	64.06	64.10	40.55	98.14	27.39

[a] Volume of saturated air containing 1 lb. of water vapour.

TABLE VI.

Weight in Grammes of 1 Litre of Gas at Atmospheric Pressure (760 mm. Mercury).

Temperature.		Air.	Oxygen.	Nitrogen.	Carbon mon-oxide.	Carbon dioxide.	Steam.	Sulphur dioxide.
Deg. F.	Deg. C.							
100	38	1.1360	1.2560	1.0990	1.0980	1.7370	0.04533[1]	2.5690
150	66	1.0420	1.1530	1.0090	1.0080	1.5940	0.1651[1]	2.3580
200	93	0.9634	1.0650	0.9321	0.9318	1.4730	0.4767[1]	2.1800
250	121	0.8957	0.9899	0.8664	0.8663	1.3690	0.5659	2.0260
300	149	0.8367	0.9249	0.8094	0.8092	1.2800	0.5288	1.8930
350	177	0.7849	0.8679	0.7596	0.7595	1.2000	0.4961	1.7760
400	204	0.7392	0.8172	0.7152	0.7150	1.1330	0.4673	1.6720
450	232	0.6987	0.7724	0.6760	0.6758	1.0680	0.4415	1.5810
500	260	0.6623	0.7320	0.6407	0.6406	1.0130	0.4184	1.4990
550	288	0.6295	0.6958	0.6090	0.6088	0.9628	0.3977	1.4250
600	315	0.5998	0.6630	0.5803	0.5802	0.9173	0.3790	1.3570
650	343	0.5728	0.6332	0.5542	0.5541	0.8760	0.3619	1.3080
700	371	0.5481	0.6058	0.5302	0.5301	0.8382	0.3462	1.2400
750	399	0.5253	0.5808	0.5083	0.5081	0.8034	0.3317	1.1890
800	426	0.5045	0.5578	0.4882	0.4880	0.7715	0.3186	1.1420
850	454	0.4853	0.5365	0.4695	0.4693	0.7421	0.3064	1.0980
900	482	0.4674	0.5168	0.4522	0.4521	0.7148	0.2952	1.0580
950	510	0.4509	0.4983	0.4362	0.4360	0.6895	0.2848	1.0200
1,000	538	0.4354	0.4813	0.4213	0.4211	0.6659	0.2750	0.9854
1,050	566	0.4209	0.4653	0.4073	0.4072	0.6438	0.2659	0.9528
1,100	594	0.4075	0.4504	0.3942	0.3941	0.6232	0.2574	0.9223
1,150	621	0.3948	0.4365	0.3820	0.3819	0.6038	0.2494	0.8937
1,200	649	0.3830	0.4232	0.3705	0.3704	0.5855	0.2419	0.8666
1,250	676	0.3718	0.4109	0.3596	0.3595	0.5684	0.2348	0.8413
1,300	704	0.3612	0.3992	0.3495	0.3494	0.5524	0.2281	0.8175
1,350	732	0.3513	0.3881	0.3397	0.3396	0.5370	0.2219	0.7948
1,400	760	0.3418	0.3777	0.3306	0.3305	0.5226	0.2158	0.7734
1,450	788	0.3328	0.3678	0.3220	0.3218	0.5088	0.2102	0.7532
1,500	815	0.3244	0.3585	0.3138	0.3136	0.4960	0.2049	0.7340
1,550	843	0.3162	0.3497	0.3060	0.3058	0.4837	0.1997	0.7157
1,600	871	0.3085	0.3410	0.2986	0.2984	0.4718	0.1949	0.6984
1,650	899	0.3013	0.3330	0.2914	0.2913	0.4607	0.1903	0.6819
1,700	927	0.2942	0.3253	0.2846	0.2846	0.4500	0.1858	0.6660
1,750	955	0.2875	0.3179	0.2782	0.2782	0.4399	0.1816	0.6510
1,800	982	0.2811	0.3109	0.2722	0.2721	0.4301	0.1776	0.6366
1,850	1,010	0.2752	0.3042	0.2662	0.2661	0.4208	0.1738	0.6228
1,900	1,038	0.2693	0.2978	0.2606	0.2605	0.4119	0.1701	0.6097
1,950	1,066	0.2638	0.2915	0.2552	0.2551	0.4032	0.1666	0.5970
2,000	1,093	0.2584	0.2856	0.2500	0.2499	0.3951	0.1632	0.5848

[1] Grammes of water-vapour per litre of saturated air.

TABLE VII.

VOLUME IN LITRES PER GRAMME OF GAS AT ATMOSPHERIC PRESSURE
(760 MM. MERCURY).

Temperature.		Air.	Oxygen.	Nitrogen.	Carbon mon-oxide.	Carbon dioxide.	Steam.	Sulphur dioxide.
Deg. F.	Deg. C.							
100	38	0.8803	0.7962	0.9099	0.9107	0.5757	22.060[2]	0.3893
150	66	0.9597	0.8673	0.9911	0.9921	0.6274	6.057[2]	0.4241
200	93	1.038	0.9390	1.073	1.074	0.6789	2.098[2]	0.4581
250	121	1.116	1.010	1.154	1.155	0.7305	1.767	0.4936
300	149	1.195	1.081	1.235	1.236	0.7813	1.891	0.5283
350	177	1.274	1.152	1.316	1.317	0.8333	2.016	0.5631
400	204	1.353	1.224	1.398	1.399	0.8826	2.140	0.5981
450	232	1.431	1.295	1.479	1.480	0.9363	2.265	0.6325
500	260	1.510	1.366	1.561	1.562	0.9872	2.390	0.6671
550	288	1.589	1.437	1.642	1.643	1.039	2.514	0.7018
600	315	1.667	1.508	1.723	1.724	1.090	2.639	0.7369
650	343	1.746	1.579	1.804	1.805	1.142	2.763	0.7645
700	371	1.824	1.651	1.886	1.887	1.193	2.889	0.8065
750	399	1.904	1.722	1.967	1.968	1.245	3.015	0.8410
800	426	1.982	1.793	2.048	2.049	1.296	3.139	0.8757
850	454	2.061	1.864	2.130	2.131	1.348	3.264	0.9107
900	482	2.139	1.935	2.211	2.212	1.399	3.388	0.9452
950	510	2.218	2.007	2.293	2.294	1.450	3.511	0.9804
1,000	538	2.297	2.078	2.374	2.375	1.502	3.636	1.015
1,050	566	2.376	2.149	2.455	2.456	1.553	3.761	1.050
1,100	594	2.454	2.220	2.537	2.538	1.605	3.885	1.084
1,150	621	2.533	2.291	2.618	2.619	1.656	4.010	1.119
1,200	649	2.611	2.363	2.699	2.700	1.708	4.134	1.154
1,250	676	2.690	2.434	2.781	2.782	1.759	4.259	1.189
1,300	704	2.769	2.505	2.861	2.862	1.810	4.384	1.223
1,350	732	2.847	2.577	2.944	2.945	1.862	4.507	1.258
1,400	760	2.926	2.648	3.025	3.026	1.914	4.634	1.293
1,450	788	3.005	2.719	3.106	3.108	1.965	4.757	1.328
1,500	815	3.083	2.789	3.187	3.189	2.016	4.880	1.362
1,550	843	3.163	2.860	3.268	3.270	2.067	5.008	1.397
1,600	871	3.241	2.933	3.349	3.351	2.120	5.131	1.432
1,650	899	3.319	3.003	3.432	3.433	2.171	5.255	1.466
1,700	927	3.399	3.074	3.514	3.514	2.222	5.382	1.501
1,750	955	3.478	3.146	3.595	3.595	2.273	5.507	1.536
1,800	982	3.557	3.216	3.674	3.676	2.325	5.631	1.571
1,850	1,010	3.634	3.287	3.757	3.758	2.376	5.754	1.606
1,900	1,038	3.713	3.358	3.837	3.839	2.428	5.879	1.640
1,950	1,066	3.791	3.431	3.918	3.920	2.480	6.002	1.675
2,000	1,093	3.870	3.501	4.000	4.002	2.531	6.127	1.710

[2] Volume of saturated air containing 1 gr. of water vapour.

Recent Patents Relating to Cement.

Cements and Mortars.

428,130 Halbach, K., Rochusstrasse, Düsseldorf, Germany. Oct. 4, 1933.

Portland or slag cement or like hydraulic material is hydrated with sufficient water, and under such conditions, e.g., agitation, that a pasty gel-like mass is obtained ; this is dried and ground and mixed with untreated cement for the production of concretes in which the ratio of tensile to compressive strength is about 1 : 6, and which can be rolled during setting. The production of the gel can be facilitated by the use of hot water or steam, or by treatment with carbon dioxide or dilute mineral acids. The gel may be ground with the cement clinker. Fillers, setting-regulators such as plaster of Paris, and the like, may be added, if desired, during the making of the gel. As filler, cement clinker is suitable, and may be added to the top layer only in road making so as to break down gradually under traffic.

According to an example, 50 parts of Portland cement are mixed with 50 to 100 parts of water until a gel-like paste is obtained. This is dried and ground and mixed with an equal quantity of Portland cement. This is mixed with cement clinker in the proportion of 1 : 2.

After 28 days a tensile strength of about 91 kg. and compressive strength of 475 kg. are obtained.

Cements and Mortars.

428,192. Heimann, B., 22, Marktstrasse, Batteln, Westphalia, Germany. Oct. 22, 1934.

A composition for adding to cement and mortar materials to produce waterproof masses comprises approximately 5 parts by weight each of barium sulphate, caustic lime, glass grinding sand, and aluminium silicate, 50 parts of powdered waterglass, 130 parts of colloidal silicic acid and 2 parts of a hydrofluorsilicic acid salt, preferably of magnesium. All the ingredients are ground to pollen-like fineness and the dry mixture is added to the dry cement and mortar materials in proportions of ½ to 2 per cent. by weight.

In a modification the additive composition comprises approximately 30 parts by weight each of caustic lime, glass grinding sand, aluminium silicate, and powdered waterglass, 60 parts of colloidal silicic acid, 2 parts of a hydrofluorsilicic salt preferably of magnesium, and 10 parts of a fatty acid salt, e.g. aluminium palmitate or stearate.